Incorporating HamSCI Project into a College Physics Course: A Progress Report

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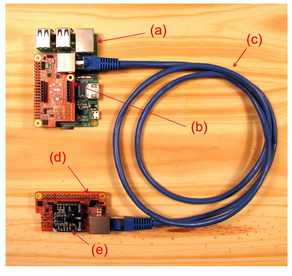
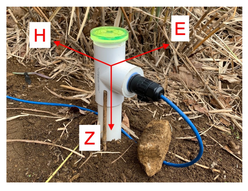
Introduction

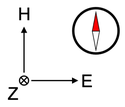
- We report citizen science activity in a physics course to engage undergraduate students in the HamSCI Personal Space Weather Station (PSWS) project.
- The Physics Department at the New Jersey Institute of Technology (NJIT) offers a senior-level lab course, "Advanced Physics Lab." In this course, students gain hands-on experience in the quantitative measurement of fundamental physical parameters across various fields of physics.
- Students conduct lab experiments in an unstructured environment, where they are provided with equipment and manuals to complete tasks with minimal supervision from the instructor.
- Historically, students have been provided with pre-set lab equipment and followed specific lab assignments. While this approach helps students relate their experimental results to established physics theories and principles, its impact is limited due to the lack of sufficient "hands-on" experience and the demonstration of real-world applications.
- The HamSCI PSWS project provides an excellent opportunity to address this gap. Through the project, students build and test scientific instruments, using them for investigations that engage them directly in scientific inquiry.
- Throughout the course, class activities and their impact on future workforce training will be evaluated, utilizing HamSCI resources.

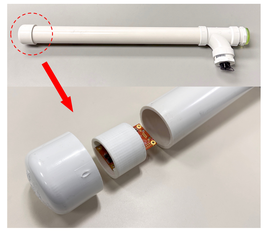
HamSCI Personal Space Weather Station (PSWS)

• Magnetometer



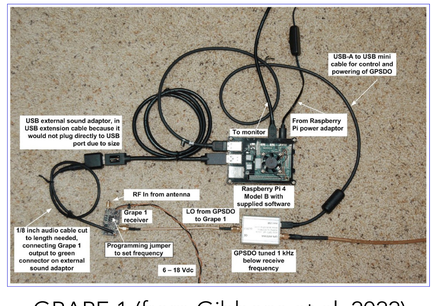




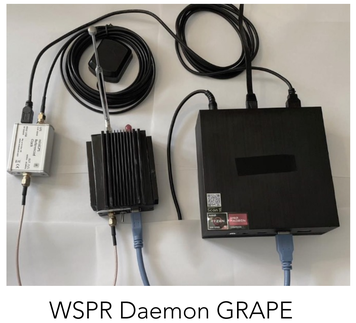


HamSCI magnetometer boards (left), ground installation (middle) and sensor housing (right) (from Kim et al., 2024).

• Great Radio Amateur Propagation Experiment (GRAPE)


USB-A to USB mini cable for control and powering of GPSDO
USB external sound adaptor, in USB extension cable because it would not plug directly to USB port due to size
To monitor
From Raspberry Pi power adaptor
RF In from antenna
Raspberry Pi 4 Model B with supplied software
Grape 1 receiver
LO from GPSDO to Grape 1
1/8 inch audio cable cut to length needed, connecting Grape 1 output to green connector on external sound adaptor
Programming jumper to set frequency
6 – 18 Vdc
GPSDO tuned 1 kHz below receive frequency

GRAPE 1 (from Gibbons et al. 2022)

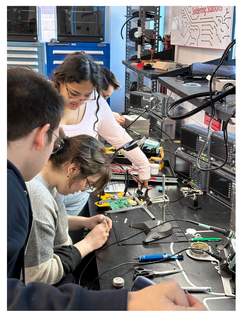


WSPR Daemon GRAPE

Student Activities

• PHYS 450: Advanced Physics Lab

The class meets once a week at the physics lab or NJIT Makerspace. The Makerspace is the largest (21,000 sq ft) educational facility of its kind in NJ.



The students build and test the PSWS instruments.

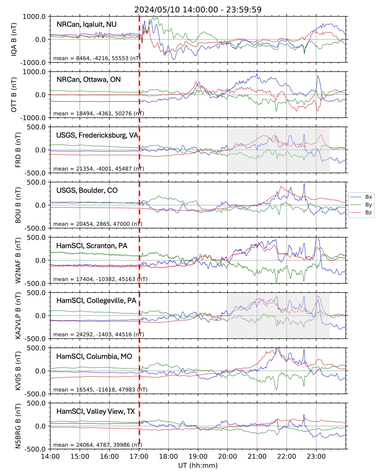
• ROTC Space Force Cadet Training

Collaboration with NJIT's ROTC program for Space Force cadet training: An opportunity to learn about space weather, RF communication, remote sensing, etc.

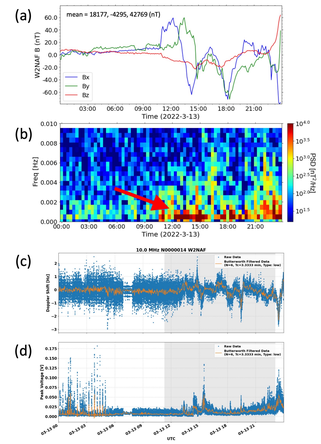
• Achievements

- PHYS 450 students: six in Spring 2024; six in Spring 2025.
- Two undergraduate RAs.
- Five Space Force ROTC cadets (non-physics/engineering major).
- One magnetometer, two GRAPE-1, and one WSPR Daemon GRAPE have been installed on campus.

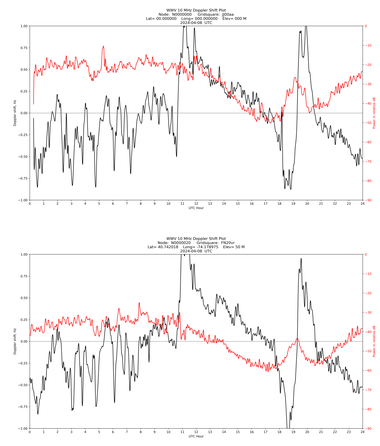
PSWS Observations



A geomagnetic storm (May 10, 2024) observed by the HamSCI magnetometer systems installed at four locations (bottom four panels) along with the professional science-grade magnetometers operated by US and Canadian agencies (top four panels) (from Kim et al. 2024).



Geomagnetic pulsations during a geomagnetic storm on March 13, 2022. The time series plot (Panel (a)) and spectrogram (Panel (b)) showing geomagnetic pulsations (~2 to 7 mHz). Doppler shifts (Panel (c) and amplitude variations (Panel (d)) in the HF signals received by the co-located GRAPE HF receiver (from Kim et al. 2024).



Observations of Doppler shift of WWV signal at 10 MHz during the solar eclipse on April 8, 2024. (Top) GRAPE-1 at Holland Patent, NY (99.9 totality); (Bottom) GRAPE-1 at New Jersey Institute of Technology, NJ (90% totality). Credit: Sabstian Fernandes, Joseph Visone, Anneliese Schmidt

References

Kim et al. (2024) , Citizen science: Development of a low-cost magnetometer system for a coordinated space weather monitoring, HardwareX, Volume 20, e00580.

Gibbons et al. (2022), Grape Version 1: First prototype of the low-cost personal space weather station receiver, HardwareX, Volume 11, e00289

Acknowledgements

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